Maximizing the Utilization and Impact of Medical Educational Software by Designing for Local Area Network (LAN) Implementation

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The design, development and implementation of medical education software often occurs without sufficient consideration of the potential benefits that can be realized by making the software network aware. These benefits can be considerable and can greatly enhance the utilization and potential impact of the software. This article details how multiple aspects of the IMMEX problem solving project have benefited from taking maximum advantage of LAN resources.

INTRODUCTION

The rapidly emerging information technologies and the integration of computers into health professions curricula hold the promise of revolutionizing the way education and performance assessment is conducted. Recent reports have indicated however that fulfilling this promise has been elusive [1,2].

The creation and implementation of meaningful curricula materials is time consuming and expensive, hampered by little funding, the lack of faculty technology experience, the lack of faculty time and rewards and often the widespread distribution of development resources [3]. Most software produced lacks built-in components enabling it to be extended for use in evaluating students or to determine how the software impacted students' learning. These events in turn delay the development and refinement of evaluation tools and evaluation research studies.

Given these issues, it becomes important when designing educational software to maximize development efforts and subsequent software utilization. Local area networks (LAN's) can potentially be very useful in this regard. In an ironic sense this approach is not new and brings educational software development and implementation back to its mainframe roots, i.e. PLATO, albeit in an environment richer in connectivity and resources [4].

This article details how one educational software development project, the IMMEX Problem Solving Software project has incorporated the multiple resources provided by the UCLA Local Area Networks to diversify and expand the utilization of the developed materials.

THE IMMEX PROBLEM SOLVING ENVIRONMENT

IMMEX is a Windows-based development and implementation software environment which simplifies the construction of problem solving modules in multiple disciplines. This software is unusual in that it subsequently allows the evaluation of individual student's or groups of students' performances on these problems [5-7]. This enables faculty to determine not only if students solved a problem but also how information was gathered and interpreted during the process. The software consists of three modules: IMMEX::AUTHOR and DELIVERY simplifies the generation and delivery of problem solving modules, IMMEX::ANALYSIS is a graphical interface into the database of student performances which diagnostically maps students problem solutions, and IMMEX::NEURAL which is trainable neural network software which 'learns' from successful student problem approaches and can enhance the evaluation of subsequent students performances by functioning as an electronic critic [8]. The modular nature of the software and the implementation across LAN's has allowed the software to be used in multiple educational settings as shown in Table 1.

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TABLE 1

IMMEX ACTIVITIES SUPPORTED BY LAN's

Activity	LAN Advantages
Instruction	Program usage data Problem validation Version control
Examination	Security Network utilization
Informatics	Training Sharing of computing resources
Research	Data Consolidation Data Sharing

The central role that LAN's play in each of these activities are highlighted in this article.

METHODS/RESULTS

The UCLA School of Medicine Backbone Configuration

In early 1990, the UCLA School of Medicine designed a computer network backbone to provide electronic connectivity for faculty, staff, students and clinicians [9]. This backbone was designed to support the needs that are inherent to a school/hospital complex such as UCLA. The needs included electronic mail, bulletin board services, Medline searches, clinical data management systems, digital image transfer, educational software, knowledge banks, electronic student notebooks, and downloading of administrative/clinical information from the campus computer systems. The backbone had to be modular and expandable to effectively deal with the increasing use of computers in the medical environment. Most importantly the network had to be highly reliable to support mission critical projects.

Currently there are 68 Local Area Networks (LAN's) that are connected to the UCLA School of Medicine Backbone. All of the LAN's support electronic mail (e-mail) systems which are connected to a central post office. Every e-mail system on the School backbone can communicate by Simple Mail Transfer Protocol (SMTP) using gateways. There is no standardization of software and hardware across departments in the School although most of the operating systems supporting the LAN's are Novell Netware. The token ring backbone is running at 16 Mbps. The School's backbone provides connectivity to the UCLA campus fiber optic network thus extending its reach throughout UCLA, as well as nationally and internationally. The campus backbone provides links to BITNET, NSFnet, CERFnet, and BARRnet through leased T1 lines, fiber and microwave [10].

IMMEX Environment

The IMMEX Software Development Laboratory contains a file server running Novell Netware 3.11 with 1.2 gigabyte storage capacity. This file server is connected by token-ring to 4 PC workstations; ports are also available for notebook computer access. The file server also services an ethernet subnet which connects an Apple Quadra 700, a NeXT color workstation and a Next Cube with a NeXT Dimension board. The IMMEX LAN is attached to the UCLA School of Medicine Backbone allowing utilization of IMMEX resources throughout the medical school.

Authoring and Delivery of Problem Solving Modules

The most traditional use of educational software is for presentation of new or review material. The IMMEX environment expands on this use by allowing faculty to create new software and/or to modify existing IMMEX modules to more completely satisfy local curricular goals. This use of the software is enhanced by implementation on a LAN by expediting the expert validation of the developed software and by allowing the collection of program statistics. During the development process, faculty and student authors share modules for validation purposes. LAN implementation enriches this process by simplifying version control. Only a single copy of the most recently modified software is present on the network and all participants can actively engage in the revision process without the exchange of diskettes. For the purposes of the collection of program usage statistics, LAN implementation has allowed us to yearly determine student usage of the programs. Such information is useful for documenting the cost/benefit aspects of the software. For instance,

during the past academic year the Immunology problem solving modules were used 1014 times at UCLA and 973 times at George Washington University for student practice and examination. The Infectious Disease modules were used 602 times at UCLA for a total of over 1800 student contact hours. Pooling of similar data over the seven years that IMMEX has been used in our curriculum has allowed us to estimate that currently the development and implementation costs have averaged ~ $5.00 per hour of student usage. With continued expansion of the program and utilization of the software at other sites, this cost is likely to drop significantly. These cost-benefit estimates will be developed more fully in a separate manuscript.

The LAN implementation of IMMEX also facilitates more detailed data collection of student performances. Each IMMEX module contains transaction log facilities where the details of student performances are recorded. Network implementation of the software greatly simplifies the retrieval of this data from a single server-based database rather than from multiple databases distributed across machines. This affords the opportunity for using the software for evaluating students performance.

Implementation of Problem Solving Software for Testing Students

Utilization of developed programs for evaluating the students, places the highest degree of stringency on the software [11]. In this setting, there is usually a limited time frame for implementation; furthermore, this process must be reliable, data must be captured, verified and eventually analyzed and security must be high. While not many institutions are experimenting with this form of student evaluation, the number is increasing.

For the past seven years, 150-160 students in the Immunology section of the curriculum have had up to 50% of their grade dependent on solving multiple IMMEX modules. In these testing situations, students select a 1-2 hour time slot when they are assigned one of 15 computers in the Biomedical Library Microcomputer Facility. During the 1992 academic year, 9 problems were randomly presented and students worked on these problems until 2 were solved. This resulted in nearly 400 student hours of program usage during a 4 day time period.

All of the test problems were maintained on the IMMEX LAN. These were remote from the testing site in directories flagged for supervisor only access until the day of the examination. The drive containing the problems was mapped to the attached networked machines only during examination hours. The mapping was removed on a daily basis during off periods. This helped to maintain security. All of the student performance data was collected on the IMMEX server in order to continuously monitor workstation usage and student logons. These databases were backed up periodically and were available in the event of database corruption.

Delivery across the backbone also provided additional information regarding utilization of the backbone resources. The average utilization of the School backbone was 11% prior to the examination period. This figure rose 0.5% during the 4 days of testing indicating that multiple time intensive computing activities such as examinations could occur concurrently without appreciably degrading network performance.

LAN Utilization for Software Development and Informatics Activities

Authoring of IMMEX problem solving modules occurs at two levels at UCLA. As described above, the faculty create software modules for their courses throughout the year. In this capacity, the configuration of the IMMEX LAN is important for integration of diverse resources. For instance, images are captured on one machine (NeXT) by digital scanning or via live or taped video. These images, particularly large ones are transferred via FTP (File Transfer Protocol) over the ethernet to an Apple Quadra 700 where they are manipulated/enhanced and registered into a specific database on the server. This database of image (and text) resources can then be accessed by software developers throughout the School as additional software modules are created.

The second level of authoring is unique to the UCLA School of Medicine and strongly relies on the LAN architecture. For the past two years, *students* have been involved in authoring IMMEX modules as group team projects. In this format, 6-12 students are assigned an immunological topic (such as a selective deficiency of transplantation molecules) and each group constructs a complete IMMEX

problem over a period of 8 weeks. The pedagogical rationale was that if it takes significant integration of content to *solve* these problems it would likely take a fuller understanding to *author* these software modules. Additionally, it was felt that this educational format would promote informatics awareness and teamwork skills among the class.

Each year between 40 and 150 students have participated in these programming activities. Within each of these groups, students have had specific assignments, all which make significant use of the LAN for communication and resource transfer. Some students receive specialized training in Medline access over the network and become the information resource locators for their group. Others are provided Internet e-mail accounts to allow communication between the group and the UCLA faculty and faculty at other institutions. Still other students are assigned the tasks of digitizing X-rays and preparing histological slides for incorporation into the software. Other students become the program authors and create the menu structures and graphics and text associations for the various tests. In this regard, the students have reported that the 'programming' of the software is not a time consuming activity. Less than 10% of the total project time has been specifically devoted to programming. As the projects proceed, the students sporadically participate depending on their class schedule. Version control could become a major factor. LAN implementation assures that there is only one current version of the software and database. It further assures that available text and image resources can be accessed by the members of the group at different times and at different sites.

Within each group there are also several students who become trained in IMMEX::ANALYSIS, and the use of Structured Query Language (SQL) tools for examining how their problems are being performed by their classmates.

Educational and Cognitive Science Research

The capture of student performance data into a single database provides the opportunity for innovative educational and cognitive science research studies. Several years ago we implemented the IMMEX::ANALYSIS software for revealing student strategies as they progress through the problem solving simulations. This visualization software gives the authors of developed IMMEX modules a unique view of how problems are solved by individual students and groups of students. In assessment situations, this software is important for documenting students problem solving strategies [5-8]. For the authors, this software also reveals if the problems are performing as intended. If for instance, the students' selection of one particular piece of information invariably reveals the solution to the problem, the author can appropriately modify the problem making it more difficult. Similarly, if students performances reveal extensive searching by most students and failure to solve the problem, the author can take the appropriate action.

Lastly, the accumulation of data over a series of years allows a more longitudinal view of the educational process, and encourages the development of additional evaluation/educational tools involving such advanced software as artificial neural networks [8].

The Down Side of LAN Implementation

The above experiences demonstrate the multiple ways that developing for LAN implementation can enhance the utility of educational software. While these experiences are for the most part positive, designing for LAN implementation can involve additional issues which may not be trivial. For instance, extra programming may be required to make software network aware. For the most part this has not been a major complication for the IMMEX project. In the past, network implementation of databases often required special programming to prevent multiple users from accessing the same information simultaneously. This is now less of a problem.

A second issue and one less easily controlled, arises if the software is to be ported to other institutions supporting LAN implementation. LAN's exist in many configurations; data is transferred by multiple protocols and implementation across a backbone may involve multiple network operating systems. In fact, it may not be too extreme to suggest that each LAN has its own unique features. As most educational software development sites lack the facilities to test their software under multiple LAN configurations, uncomplicated implementation on networks at other sites might be an over-optimistic expectation.

LAN Extensions

The School of Medicine's fiber optic network is the electronic adhesive that interconnects its departments and its administrative, research and educational activities. Computer technology (both hardware and software) however is rapidly evolving; thus, the School's network must also evolve. Enhancements that are in the foreseeable future include support for general informatics activities such as one login throughout the medical center, the integration of hospital and medical school e-mail systems and the implementation of Asynchronous Transfer Mode (ATM) and Fiber Distributed Data Interface (FDDI). Additional extensions under development will include the offering and supporting of client/server technology on the backbone and the potential for remote node access, transmission of images and multimedia data across network.

How will these opportunities enhance the educational activities of IMMEX? Re engineering of the IMMEX application to a client-server architecture will enable the transfer of only data requested over the network and will make remote node access over phone lines a reality. In addition, this architecture will allow data from student performances on multiple modules (Immunology, Infectious Disease, Surgery, etc.) to be stored in a single database. Here for instance, it can begin to serve as a central educational resource for investigating students' problem solving performances across disciplines.

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